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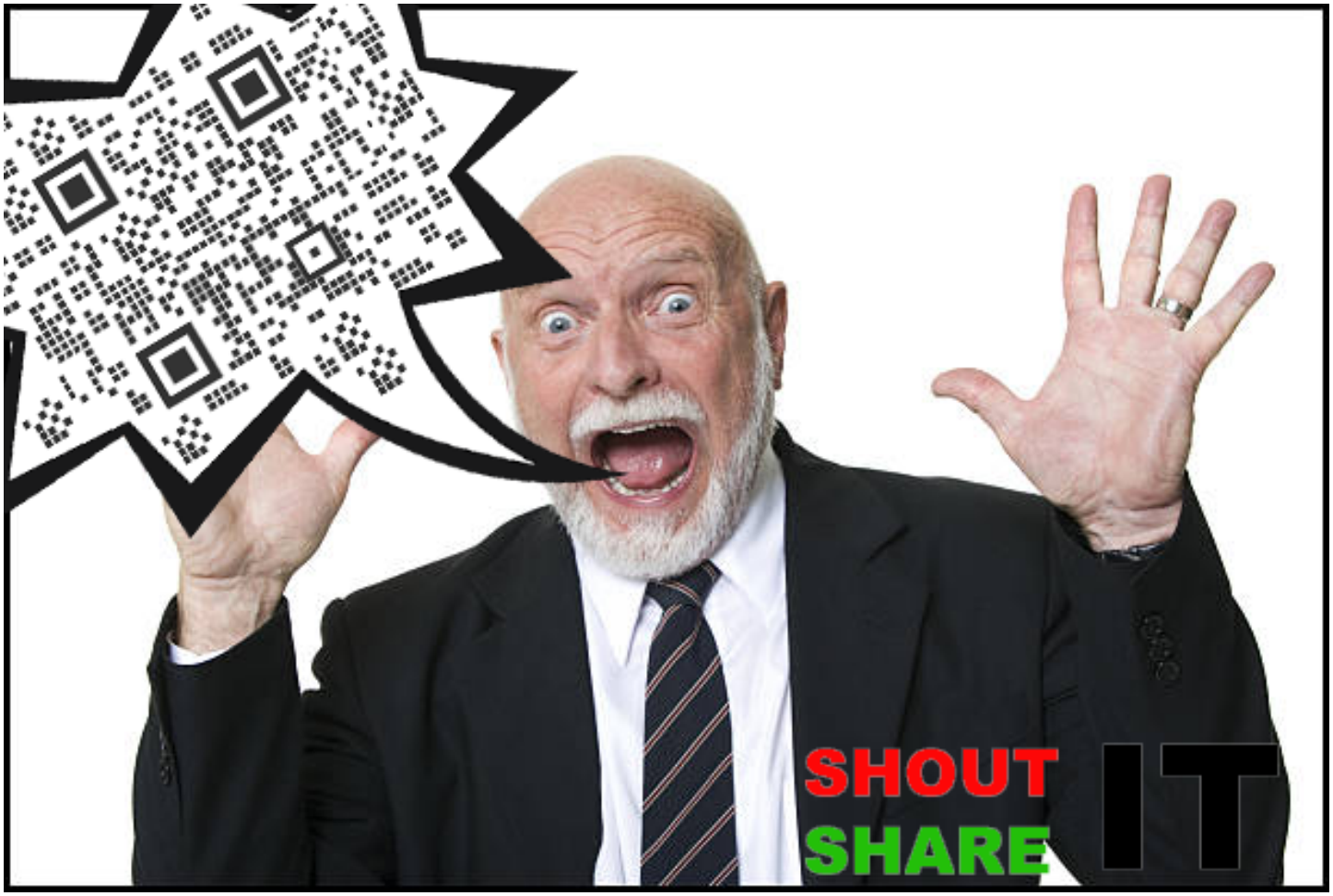
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PORTO RICO AGRICULTURAL EXPERIMENT STATION,

D. W. MAY, Special Agent in Charge.

Mayaguez, April, 1905.

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THE YAUTIAS, OR TANIERS, OF PORTO RICO.

BY

O. W. BARRETT,

Botanist and Entomologist, Porto Rico Agricultural Experiment Station.

UNDER THE SUPERVISION OF

OFFICE OF EXPERIMENT STATIONS,

U. S. DEPARTMENT OF AGRICULTURE.

WASHINGTON:

GOVERNMENT PRINTING OFFICE.

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[Under the supervision of A. C. True, Director of the Office of Experiment Stations, United States Department of Agriculture.]

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D. W. May, *Special Agent in Charge and Animal Husbandman.*
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Withdrawn
8/12/18

LETTER OF TRANSMITTAL.

PORTO RICO AGRICULTURAL EXPERIMENT STATION,
Mayaguez, P. R., April 25, 1905.

SIR: I have the honor to transmit herewith a bulletin on the yautias, or taniers, of Porto Rico, by O. W. Barrett, botanist and entomologist of this station, and respectfully recommend its publication as Bulletin No. 6 of the Porto Rico Experiment Station.

The yautia, or tanier, has been known and cultivated from the earliest historic times—in fact it was probably one of the first plants cultivated by man. However, little improvement has been made in its culture, and botanically it is often confused with plants quite dissimilar. It is hoped, therefore, that this publication will result in bettering a crop that fills a large place in the food supply of tropical America and also in clearing up some of the misconceptions regarding its botany and uses.

Respectfully,

D. W. MAY,
Special Agent in Charge.

DR. A. C. TRUE,
Director Office of Experiment Stations,
U. S. Department of Agriculture, Washington, D. C.

Recommended for publication.
A. C. TRUE, *Director.*

Publication authorized.
JAMES WILSON,
Secretary of Agriculture.

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THE YAUTIAS, OR TANIERS, OF PORTO RICO.

INTRODUCTION.

In view of the fact that no publication on this subject is thus far available, and in consideration of the growing interest in this, perhaps the oldest cultivated crop in the world, it is deemed expedient to offer the following notes. Moreover, until recently a deplorable confusion has existed between the taro, so common throughout the warmer regions of the Old World, and the tanier, which is distinctively a tropical American species. This remarkable, if not unique, case of confounding two of the most important food plants in the Tropics demands attention.

There are three reasons which may account for this ambiguity of names: (1) The flowers are seldom seen, and, except in some varieties of taro, it is highly improbable that any seed is ever produced; (2) the large size and leathery texture of the floral organs, together with the tendency to rapid decay in very humid climates, has rendered the preparation and preservation of herbarium specimens almost impossible; and (3) the similarity in habit and culture and the perplexing interchange of local names for the numerous varieties of each species, together with the wide variation of varietal names in different localities, have naturally deterred botanists as well as horticulturists from taking a firm stand against popular ideas.

Without entering upon a technical discussion of the specific differences we will dismiss the taro (*Caladium colocasia*[a]) with the brief statement that the leaf of all its varieties is peltate, i. e., the petiole is attached to the under surface of the blade at a point more or less remote from the margin; whereas the yautia leaf is never peltate, but has the leafstalk attached to the very margin of the blade. This striking difference will determine at a glance to which genus a plant belongs. (See Pl. I.)

Both from a cultural and from a dietetic standpoint the yautia holds third place among the root crops of Porto Rico. This plant, though of lower taxonomic rank than the sweet potatoes and yams, possesses many points of superiority over either, and few, if any, economic plants deserve more careful ecological study.

[a]Syn. *Colocasia antiquorum esculentum* Schott. See Contrib. Nat. Herb., 9 (1905), p. 208.

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As a family the Araceæ, to which the yautia belongs, are generally of no great value to agriculture; but the tribe Colocasieæ is of vast importance, since it includes the forty or fifty taros (*Caladium* spp.) of Polynesia, the Alocasias of the Orient, and the West Indian genus Xanthosoma, which contains four economic species and some thirty or more varieties known as taniers, tannias, cocoes, or eddoes in the British West Indies, as taye in the French West Indies, and as yautia, or malanga, in the Spanish Antilles.

GENERAL DESCRIPTION.

Though possessing no true stem, the yautia is a plant of striking appearance. The general aspect is like that of the taro, or elephant's ear, so much used as a summer ornamental in the North; but the leaves are always arrow-shaped instead of shield-shaped and with prominent venation on both surfaces. The height of the plant ranges from 1 foot in some types to 8 feet in others, and the color runs from pale green with whitish petioles to purplish olive with blackish-mauve petioles and veins. The leaves at first stand erect above the rhizome, but gradually droop and after a few months die, remaining attached by their bases to the top of the root.

In the three cultivated species—*Xanthosoma sagittæfolium*, *X. atrovirens*, and *X. violaceum*—the basal sinus of the leaf blade is always open, and the pair of strong veins running backward at an angle of about 130° with the midrib and supporting the basal lobes are usually naked on the sinus margin for ½ to 1 inch. The exterior angle of the basal lobe is in most varieties nearly acute; in *X. hastifolium*, the "Belembe," the basal lobe is produced and is more or less out of plane with the anterior portion of the blade. The blade in most varieties is strongly concave but in several is nearly flat. A glaucous bloom covers the upper surface in all varieties, and is impervious to water except on the older leaves. The veins are very prominent on the under surface. A marginal canal connects the tips of the side veins and opens by large pores onto the margin itself, through which it occasionally discharges excessive water, as, for instance, in sunshine immediately after a rain; this phenomenon of "weeping" occurs much more commonly in young plants.

The thick petiole has a broadly excavated sinus extending more than halfway from the base to the blade; the character and markings of the margins of this sinus are very important in the recognition of varieties when the roots can not be examined. The base of the petiole retains the dew and rain guided thither by the wings of the channeled sinus.

The leaf veins, petioles, stem, tubers, and roots possess laticiferous ducts containing a yellowish latex which rapidly turns brownish upon

FIG. 1.—YAUTIA, SIX-MONTHS-OLD PLANT, SHOWING HASTATE LEAF.

FIG. 2.—TARO, SHOWING PELTATE LEAVES AND NONTUBEROUS RHIZOME.

exposure to the air and forms a viscid gum. The true sap indelibly stains white cloth a reddish brown.

In old plants of several varieties, especially the "Palma," the erect "stem" is mostly above the surface of the soil and may vary from 2 inches to 2 feet in length, and from 2 inches to 6 inches in diameter. It is covered with a brownish or grayish-black fibrous epidermis. Around its upper and thicker portion are more or less prominent small "eyes," which mark the axils of fallen leaf bases. The color, shape, etc., of these "eyes" vary constantly with the variety. Scattered among and below these rings of eyes are larger buds which may develop into tubers, or, if exposed to light and air, into side shoots. On blocks of the cut stem planted in moist soil these large stem buds almost invariably throw up leafy suckers instead of forming tubers, wherefore the top only of the stem is much preferred for propagation.

The tubers are morphologically merely specialized horizontal branches of the vertical rhizome, containing a higher percentage of starch, bearing eyes and roots of their own, and having a more or less prominent terminal leaf bud. The eyes of the tubers vary greatly in character according to the variety, but are usually naked and scattered.

The roots of the tuber are usually much more sparse than those of the stem. As in most Aroids, the roots are coarse but rather long; they are whitish, rather brittle, and about 3 to 4 millimeters in diameter at the base, and for the most part horizontal.

The yautia seldom flowers in ordinary cultivation. A shock to a strong, mature plant may cause it to throw out from the axil of a leaf near the center a quasipalmately subterminal cluster of terete, or flattened, peduncles of about one-third the length of the petioles. At the moment of flowering the peduncle stands erect; those bearing unopened spathes incline toward the petiole from the base of which the cluster originated; immediately upon the partial opening of the flowerets of the spadix the peduncle withers and falls, though rarely the spathe and spadix decay before the peduncle finally shrivels. The flowers of related species of plants are malacophilous; no snails, however, have been noted in those of the yautia.

The spathe, which varies from nearly white to pinkish maroon, is constricted near the base, the roundish portion below being completely closed, while the thinner, colored, upper part has a large elliptical opening disclosing the staminate portion of the spadix. The tip of the spathe is never curved and is abruptly pointed. The pistillate or basal portion of the spadix is thicker and much shorter than the staminate extremity, from which it is separated by a slightly constricted area bearing sterile stamens. Flowers of the "Martinica" variety occasionally show connate and teratological monstrosities, such as three coherent peduncles, double spathes, flat spadices, etc.

A slightly pungent, nauseous odor is noticeable in the spathe of nearly all the varieties.

No evidence has been obtained thus far of the fruiting of a yautia of any cultivated variety. Very frequently the spadix, with its flowerets, decays in the bud, but much more frequently still the flower stalk never appears at all.

The loss of reproductive power is perhaps the strongest proof of the very great age of the yautia as a cultivated crop. Even bananas, yams, and sweet potatoes occasionally produce seed. If it be true that the two latter economic plants originated in tropical America, and that the banana, as O. F. Cook concludes,[a] began to be cultivated in the Orient as a root crop, following the usage of the wild plantain (*Bihai bihai*[b]) of tropical America, then the fact that the yautia has utterly lost its ability to produce seed while native to the same region as these other plants, which have nearly lost that power, indicates that the yautia is the oldest cultivated plant in the world. This evidence is strongly supported by the theory that the idea of cultivating economic plants originated in the Caribbean region and spread thence westward around the world.[c]

Two apparently paradoxical facts may be stated in this connection: (1) The taro (*Caladium colocasia*) which is apparently native to this region and which does not produce seed here, occurs in only two or three varieties, while in Polynesia it appears under about forty subvarieties, several of which tend to produce seed; and (2) the yautia, which runs into some forty varieties here, is apparently unknown outside of tropical America.

Yautia, or yahutia, was the name applied to the plant by the Arawaks at the time of the arrival of the Spaniards. We offer the following tentative theory for the etymology of the word: "Ya," the Arawak prefix meaning *place of*, or *locality*, and the noun "hutia," the native name of a nearly extinct genus of spiny-haired rodents (Capromys) which was hunted by the Indians and which was probably abundant wherever there was a patch of esculent tubers. It is thus possible that the tubers themselves were first called after the place in which they were found.

Taro was usually distinguished by the name "yautia malanga," and "malanga" has continued as the local name for taro in Cuba, Haiti, and Porto Rico.

The origin of the name tanier is unknown. The "r" is not ordinarily pronounced by the negro inhabitants of the British West Indies, and thus the spelling, "tannia" or "tania," is frequently seen.

In Porto Rico alone of all the West Indies the native plant names

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[a] An. Rpt. Smithsonian Institution, 1903, p. 481.

[b] See Bul. Torrey Bot. Club, 31 (1904), p. 445.

[c] The American Origin of Agriculture, O. F. Cook, Pop. Science Mo., Oct., 1902.

FIG. 1.—YAUTIA VARIETY TEST PLATS.

FIG. 2.—YAUTIA PALMA.

have been carefully preserved, and many proofs of their remarkable differentiation and precision in use could be cited. The Arawak name of the island itself, "Boriquén," meant "strong man's land," and "Arawak" was the name contemptuously applied by the roving, flesh-eating Caribs to the "eaters of meal," who tilled the soil by means of the primitive wooden hoe, called "coa" in Boriquén and other large islands.

Hence it is safe to assume that "yautia," the Porto Rican name, is the oldest and most legitimate for the plant in question.

Three species of yautia exist in a wild state in Porto Rico; these are found in shaded ravines, usually near water courses. They flower freely, but no seed has been noted thus far.

The numerous varieties which have been under cultivation for perhaps many thousands of years belong to the very similar if not identical species, *Xanthosoma sagittæfolium* and *X. atrovirens*, or else to *X. violaceum*. The last is readily recognized by its purplish leaves; only two varieties of this species are known to the writer. The intense localism of the fifteen or twenty distinct native varieties of yautias in Porto Rico is difficult of explanation, and it can not be accounted for by popular preference or prejudice nor by varietal adaptability to soil conditions. Numerous cases have been noted of the absence of certain excellent varieties in districts of easy access. On the average, fully 50 per cent of the varieties in a given district are confined to that district. The most tenable theory suggested for this localization of varieties is that although all varieties were common to all sections of the island at the time of the Spanish discovery, the one hundred years of subsequent strife and sweeping changes, the extermination or absorption of the original cultivators of the plant, the existence of slavery, and the entire change of agricultural conditions in the last three hundred years have caused some varieties to become extinct in each section, and as there is little need to import others when each locality has three to six of its own, such exchange of varieties has not progressed.

GEOGRAPHICAL DISTRIBUTION.

The number of cultivated varieties in the Lesser Antilles (Pl. II, fig. 1) is about ten; Trinidad has nearly the same number, but Venezuela and Colombia appear to have only about one-half this number, though the quality of the principal varieties cultivated about Caracas is most excellent. In Central America there are three or possibly more varieties, one or two of which are in a semiwild state. Southern Mexico appears to be the northern limit of the yautia as an important root crop. Southern Brazil is probably the southern limit. Cuba has been reported to have only varieties of taro or "malanga," but since the latter is also the name of the yautia in Cuba and Santo Domingo,

and since specimens of yautias were recently received from the Estacion Agronómica at Santiago de las Vegas, Cuba, it is certain that several varieties of yautia do exist there. One of the best varieties now grown, on the west and north coasts of Porto Rico, is said to have come from Santo Domingo.

The yautia is reported as absent from the Philippine Islands, and it is stated on good authority that this crop was unknown in Hawaii until sent thither by this station in 1902. At least one species of the "Eddas" of western Africa is a Xanthosoma, which was probably introduced from some of the British West India Islands.

No record of the yautia as a crop in southern South America has been obtained. So far as known the first specimens of yautia to reach Asia (Singapore) or Australia (Ipswich, Queensland) were distributed by this station. And it appears that, although more readily propagated, more productive, and fully as palatable as the taros, which probably originated in the same region, the yautia has unaccountably remained exclusively a tropical American plant.

CULTIVATED VARIETIES.

The cultivated varieties of Porto Rican yautias may be classified under six types, more or less distinct, as follows: Blanca, Manola, Amarilla, Martinica, Vino, and Violacea.

BLANCA TYPE.

The two varieties of this type are large, vigorous growers, bearing whitish tubers of an elongated, obovoid shape.

The Rolliza of the northeastern part of the island is the most productive of all varieties tested thus far at the experiment station grounds. It also shows less tendency to "sucker" than any other variety, thus throwing its strength into the body of the tubers rather than into the leafy shoots from their tips. The tubers have but very few, appressed "eyes," and but few roots. Single tubers occasionally weigh 2½ pounds, though 1 pound is about the ordinary weight; 4 pounds is not unusual as the product of one plant. The outer surface being smooth, there is almost no waste in the kitchen. The slenderness of the base renders the tuber very easily detached from the "madre," or central rhizome. The leaf is bluish green and the petiole bears only a fine maroon line along the sinus margin; the thick leafstalks have a character which distinguishes this variety from all others—that of lopping outward as if too weak to bear the broadly triangular blade. It is one of the earliest varieties, yet keeps well for months in the ground after ripening. The "madre" is also of fairly good quality, though sold for only about one-half the price of the tubers in the market. This variety practically never flowers. On

account of its supposed place of origin it is sometimes known as the "Luquillo."

This variety was the only one noted in the market in Caracas, Venezuela, in the dry season. Thus far it is the only native variety which is known to occur also in Jamaica and Trinidad. A very similar variety has recently been received from Guatemala and from Cuba.

The Blanca is common throughout the island. Though closely resembling Rolliza, it is distinguished by its slender upright petiole, thinner and narrower leaf blade, and more elongated, smaller tubers having more prominent "eyes" and more roots. It seems to require a moister soil than most varieties. It is quite resistant to fungus attacks. The "madre" is inedible unless well dried, on account of the raphides (crystals of calcium oxalate) contained in its circumferential portion. It is a late variety, requiring nearly twelve months to mature. This name is commonly applied also to the true Rolliza in the vicinity of Mayaguez. This is almost the only variety of which the flower has never been noted in our plats.

MANOLA TYPE.

This type is distinct from all others in the flatness of the leaf blade.

The Manola appears to be confined to the western end of the island. It resembles the Rolliza somewhat, but the shortness and flatness of the blade readily distinguish it even at a distance. The tubers, however, are yellow inside, smaller, and less numerous.

The Gengibrilla resembles the Manola in outward appearance, except that the petiole is of a lighter green and has considerable reddish-maroon shading on the inside of the sinus wings. The tubers, however, are of a pinkish shade and comparatively very slender in shape. This variety appears to be fairly productive, but the slenderness of the tubers proves an objectionable character. It is common in the vicinity of Arecibo; at Cidra it is known as "Agua" or "del Rio."

No. 32 of the station collection has the same flat blade of triangular shape as the Manola and Gengibrilla. The tubers, though much shorter, are pink as in the Gengibrilla; but the distinguishing character is the large blotches of reddish mauve on the margin of the sinus. Some of the petioles are entirely green, but usually a few irregular-shaped blotches are prominent on the inner margin. This variety is known in the Mayaguez district as "Isleña," but this name could not be used in our lists on account of the same name being applied to a distinct variety in the Ponce district.

AMARILLA TYPE.

The Amarilla of the western half of the island is a low-growing variety having gray-blue leaves, short, unmarked petioles, and short, rough tubers. The tubers are yellow or yellow orange inside and of a very firm texture. Unless boiled for a long time and mashed the

hardness of the tuber is prejudicial to its extensive use. The richness of the flavor, however, and the excellent keeping qualities commend this variety to more general cultivation. It succeeds well in dry soil and is resistant to fungus attacks. This is perhaps the latest of all varieties growing at Mayaguez, and serves to tide over the interim of scarcity until the Rolliza appears in market toward the end of the rainy season.

It has been received from only one other station in tropical America—Cuba.

Another fine variety of this type is the "Dominica" of Arecibo. This variety is known in the eastern part of the island as "Minas," and at Mayaguez as "Samanal." It is a larger plant than the "Amarilla," and is a favorite wherever grown. The leaf blade and petiole resemble those of the Isleña greatly, but the petiole bears a few blotches or stripes of a maroon color along the sinus margin. The greatest difference separating the Dominica from the Amarilla is the slender habit and pale-green leaf. The tuber in some respects is the finest flavored and richest of all the varieties of yautia tested thus far. It should be generally cultivated, since it proves fairly productive and resistant, thus far, to fungus attacks.

MARTINICA TYPE.

The Martinica is a medium-sized variety of local occurrence. In some localities it is known as "Huevo," and in others as "Quintal," or "Amarilla." The petiole shows streaks and blotches of maroon, pink, and cream along the sinus wings. It is fairly productive, but there is a tendency to overstooling, and for this reason it should be harvested early. The fair-sized tubers are more nearly cylindrical than in any other variety perhaps; they bear many roots, however, and are firmly attached to the "madre." The color is deep yellow inside, and when cooked this turns to an olive or grayish-yellow shade. They are so rich that only a few ounces suffice for the carbohydrate portion of a meal. Like the Amarilla, their firmness is a rather objectionable characteristic. This variety shows the greatest tendency to flower of all the varieties tested. Not only does it flower frequently, but teratological monstrosities have been noted in several instances, as for example double spathes, coherent peduncles, and distally flattened spadices. Unfortunately this otherwise highly desirable variety is very susceptible to fungus diseases.

The Orqueta is a small variety having pale yellowish green leaf blades on short yellowish white petioles, which bear a few streaks of maroon along the sinus margin. It appears to be known only from the south side of the island. The tuber resembles that of the Amarilla. Our tests thus far indicate that it is inferior to the Amarilla in hardiness and productiveness.

VINO TYPE.

The Vino is a small, weak-growing yautia from the north side of the island. On account of its excessive stooling habit and unproductiveness it is not generally cultivated. Its small, slender, pinkish tubers, however, are of excellent quality and present a fine appearance on the table; when boiled the well-ripened tuber becomes a deep purplish red, is flaky or "mealy," and has a delicate nut-like flavor distinct from the other varieties. The leaf blade is dark green with light-colored veins, and the petiole is stained with purple along the inner margin. The flower has not been noted. This variety is called "Punzera" in Rio Piedras and "Amadea" in Cidra.

The Isleña is a strong-growing variety having glaucous blue leaves with a long, strongly concave blade. The petiole is shaded, especially near the base, with a bluish red tinge on the inner side. The tubers, which resemble those of the Vino, are fairly prolific and of good flavor. In good soil this variety attains a height of 6 feet; much of the strength, however, is lost through its excessive "pichoneria," or stooling. This variety is common in the district north of Ponce.

VIOLACEA TYPE.

Though the two varieties of the *Xanthosoma violaceum* are frequently confused, except in a locality where both are commonly grown, they are quite distinct in all characteristics except the color of the leaf and petiole.

The "Guayamera," as it is called at San Juan, is not common in the Mayaguez and Ponce districts. The leaves of the true Guayamera are of a purplish green with maroon purple veins and blackish purple petioles, the entire surface of both blade and stalk being covered with a bluish or grayish bloom. The blade is attached at an acute angle with the petiole and thus hangs nearly vertical. It frequently attains a height of 6 feet or more. Although stooling rather badly, the yield is good and the quality of the medium-sized tubers is about equal to that of the Vino, while their color is fully as fine. It does not flower under ordinary circumstances. Though a very popular variety for home use, the tubers are almost never to be found in the market. It is rather subject to fungus attacks.

The true Prieta, or Morada, seems to be but little known in most districts of the island, though it is one of the very best varieties thus far tested. Its habit above ground is very similar to that of the Guayamera, but the leaf blades are set at right angles to the stalk and stand out, displaying the strong purple-veined ribs of the lower surface of the strongly concave blade. The tubers, however, are short, cylindrical, and of an orange-yellow color inside; the flavor is excellent.

This variety is fairly productive, attains a height of 6 feet, and is fairly resistant to fungus attacks. Thus far it has been noted in cultivation only at Rio Piedras and Arecibo.

IMPORTED VARIETIES.

Over fifteen cultivated varieties from Venezuela, Colombia, Guatemala, British Honduras, Cuba, Jamaica, Trinidad, and the Gold Coast, Africa, are under trial on the station's test plats. Most of these varieties fall into either the Rolliza or Vino types, though several tall-growing varieties somewhat resembling the Isleña in habit above ground have mauve or reddish petioles and large reddish tubers of excellent quality. On account of the extreme difficulty of securing material from Central America and Colombia, those important regions are not well represented in our collections; doubtless several good sorts new to Porto Rico might be obtained from those countries.

SEMICULTIVATED VARIETIES.

PALMA.

The Palma (Pl. II, fig. 2) is a variety found both wild and in a semicultivated state throughout the interior of the island. In times of scarcity the rootstock is used for the table, but it is usually boiled and fed to swine and poultry.

In all its parts this plant differs sufficiently from the foregoing varieties to constitute a distinct species, or at least subspecies. No description has been found by the writer.

The leaves are of an olive green, frequently 4 feet long by 3 feet broad at the base. The petiole is shaded from dull green distally to purplish maroon along the sinus. The spathe, which is frequently in evidence, is 12 to 18 inches long, slender, glaucous maroon below, shading to pinkish yellow above; the odor is rather unpleasant and pungent. The erect rhizome is 4 to 8 inches in diameter and at the age of two years may attain 2 to 3 feet in height by accretion at the top, after the manner of palms. No offsets are produced under ordinary circumstances, though small tubers with a yellowish interior have been observed in old plants. About 10 pounds is the weight of a 1-year-old rhizome; this weight would be nearly doubled, normally, at the end of the second year.

The percentage of starch in the rootstock is about the same as in that of the Rolliza; the fiber is coarser.

The Palma resists fungus attacks better than any other yautia.

BELEMBE.

The Belembe occurs wild in moist soil in the station grounds and in a semicultivated state near Arecibo and San Juan on the north side

of the island. It was not noted in the Luquillo Forest Reserve in the northeastern portion of the island. This plant is *Xanthosoma hastifolium* of C. Koch.

The peculiar concave leaves with elongated, slightly twisted basal lobes and a prominent marginal vein mark this species as very distinct from *Xanthosoma sagittæfolium*. The flower is very similar in shape but paler in color than that of the latter species; it attains only 3 to 5 inches in length. This species is stemless, and the leaves seldom stand above 1½ feet. There are no tubers, the offsets of the central root stalk sending up leaves even when very small. A clump may contain 5 to 15 suckers about the old plant.

Though of less substance than those of *X. sagittæfolium*, the Belembe leaves are preferred by the natives as a spinach.

CIMARRONA.

The Cimarrona, or Brava, is never cultivated, but occurs commonly throughout the island. It prefers moist or shaded soil. In habit it closely resembles the Belembe, but the leaf is quite different. The petiole is short with wide sinus wings, and, like the blade, is of a glaucous grayish-blue color; the midrib is placed at one side of the median line, and the other veins are not prominent in the rather thick parenchyma. The basal lobes are small and narrowed.

The spathe resembles that of the Belembe, but is more fleshy and of a yellowish-white shade.

The juice of the corm-like rhizome is yellowish at first, but soon thickens and turns dark. This juice, or the grated root itself, is used by the natives to kill grubs or maggots in sores on cattle or horses. Raphides are undoubtedly the principal agent in this effect.

FALSE YAUTIAS.

YAUTIA BRAVA.

A wild Caladium occurring as a weed in moist fields is known as Yautia Brava. The leaf, which attains a height of 8 to 12 inches, is peltate and of a dark-green shade with a coppery luster. The flower spathe is similar to that of the cultivated varieties. The corm is yellow inside and the juice is used, like that of the "Cimarrona," to kill maggots in sores.

MALANGA.

Doctor Coll y Toste believes this to be the West African name of the taro (*Caladium colocasia*), but O. F. Cook evidently considers it a genuine Arawak word. It is sometimes used by the natives as an adjective and sometimes as a substantive, evidencing their correct appreciation of the species as a plant distinct from the yautia.

Only one native variety is known. It flowers but, unlike the Trinidad and Hawaii varieties, does not produce seed.

The leaf is always peltate and the blade usually hangs nearly vertical. The roots are sold in Porto Rico at about one-half the price of the yautia tubers. The rhizome is the only part eaten, though very small offsets, like those of Yautia Palma, are sometimes produced. These roots attain 1 to 3 pounds weight in rich, moist soil in one year.

The starch grain of this root is exceedingly small, and for this reason the plant has little value as a starch producer. It is likely to be pasty when boiled.

YAUTIA DEL MONTE, OR GUAPA.

This is a very rare and interesting Porto Rican aroid described by C. Koch as *Dracontium asperum* from Brazil and apparently is not found elsewhere in the West Indies. It is found in a wild state in some parts of the island in moist, shaded soil. The single, pedately decompound, pertuse leaf attains 8 feet. The mauve, arched spathe exhales a poisonous odor. In times of scarcity of other roots the large lenticular or roundish corm is dug and eaten by the natives. The taste and appearance of the cooked root suggests squash.

Two colonies of this plant occur on the station grounds in a wild state. It does not yield readily to cultivation.

YAUTIA PANAMA.

This is the native name for *Alocasia macrorhiza*, which occurs commonly in a semiwild state throughout the island. The large rhizome contains a moderate amount of starch; it is used principally for feeding swine, and for this purpose should be cut into pieces and thoroughly boiled. On account of the insoluble crystals of calcium oxalate (raphides) contained in the cortical portion it is unsuited to use as a table root.

Even 9-foot plants have thus far resisted all attempts to shock them into flowering.

The caulescent rhizome attains a weight of 10 to 25 pounds in one or two years.

YAUTIA DEL JARDIN.

This is the local name applied to the cultivated ornamental varieties of Caladium (*Cyrtospadix* spp.).

PROPORTIONS OF DIFFERENT PARTS OF THE PLANT.

On account of the very diverse habits with regard to stooling among native types of yautias in Porto Rico, the different varieties show great variation in the percentage of net food material to the weight of the entire plant. Plate III, fig. 1, shows normal specimens of three

FIG. 1.—STOOLING OF YAUTIA. ROLLIZA (1) WITHOUT, MARTINICA (2) AND AMARILLA (3) WITH SUCKERS.

FIG. 2.—HARVESTING YAUTIA.

of the common types with offsets; and the following table indicates the plant proportions of the principal varieties:

Proportions of different parts of the yautia plant.

Variety.	Leaves.	Root-stock.	Offsets.	Tubers.	
	Pounds.	*Pounds.*	*Pounds.*	*Pounds.*	*Per cent.*
Amarilla	7.25	2.5	4.25	1.5	10
Guayamera	4.5	2.0	1.75	2.5	21
Martinica	6.0	1.25	1.75	2.5	22
Rolliza	3.5	2.25	1.50	3.75	34

The above proportions do not vary greatly during the life of the plant, since the suckers increase nearly in ratio with the increase of the tubers. The great economic superiority of the Rolliza is clearly indicated by the above table and is further brought out by its early maturity.

CULTURE.

The culture of the yautia in any frostless region of the globe presents very few difficulties; indeed, there are few if any crops which are cultivable under such a wide range of conditions.

Like most aroids it demands a good share of moisture, but let the soil be heavy clay or light sand, seacoast or mountain top, shaded ravine or sunny plain, a crop of tubers is a foregone conclusion. Though in Porto Rico only about 2 per cent of all the cultivated land is planted with yautia, it must be ranked as the third most important root crop of the island; because of its high productiveness, facility of culture, and adaptability to various conditions, it is in many respects superior to either the yam or sweet potato.

In shallow soils the yautia suffers considerably during prolonged drought; the leaf surface is reduced, and little or no development is made. In hot weather, however, with frequent showers, this plant rivals all others of its kind in rapidity of growth.

To prevent petty pilfering the family yautia plat is usually located very close to the dwelling, where it may be under the protection of the watchdogs at night. Hence no large fields of this crop are to be seen in Porto Rico; a half-acre plat is unusually large. Systematic cultivation is seldom practiced by the natives. It is sometimes planted in rows, but the hills are more often at irregular distances. Desultory weeding and hoeing is practiced, but it is probable that no horse cultivator has as yet ever graced a field of this, probably the oldest crop in the world. The natives' idea is to plant the sets so close together that when about half grown the leaves will meet and shade the interspaces, thus keeping down the weeds with no effort on the part of the planter; this method is also used in cane fields and has at least a few advantages. Close planting, however, causes slender plants and a low yield per hill.

Experiments at the station's trial grounds indicate that the best distances for ordinary soils is about 1½ by 3 feet; in good soil 1 square yard is barely enough for each plant, since many varieties, especially some of those from Jamaica, frequently stand over 6 feet high.

Eight to ten thousand plants may be set per acre.

Both the tops of the old rootstocks and the tubers themselves are used as "seed;" the former, called the "palma," is preferable because it sends up a strong leaf shoot at once after planting and tends to throw out fewer suckers. This "palma," or "head," is prepared by cutting off the tip of the old stem, leaving ½ to 1½ inches of the leafless portion and about 4 inches of the leaf bases; the dead bases of the leaf-stalks are peeled off from this head till fresh tissue is visible. In setting, the tip of the bunch of petioles is left just above the surface of the soil.

Sections or pieces of the old rootstock are also used in planting, but since each "eye" is likely to throw up a sucker, this method is used only when scarcity of good "heads" so necessitates. Similarly, the tubers are not generally used for propagation, since their still weaker "eyes" tend to produce slender, slow-growing plants.

In planting, especially in wet weather, the sets or tubers should be only lightly covered in holes 8 to 12 centimeters (3 to 5 inches) deep. The dry season, from December to April, inclusive, is usually preferred for planting. A full crop may be expected in from ten to twelve months. Tubers may be found in the markets of Porto Rico nearly every day in the year, though their price from July to October may run from 2½ to 3 cents per pound, about three times the price in the season of general harvest (January to April).

The normal price of yautia is a little less than that of the yams, but nearly double that of the sweet potato. The "madres" of Rolliza and Amarilla usually sell for one-half cent per pound, i. e., about one-half the price of the tubers.

FERTILIZERS.

The experiments thus far completed at the station grounds are not conclusive as to the requirements of the yautia in the matter of applied plant food. Like all root crops which give very heavy yields, this crop demands either a naturally rich soil or one well manured.

Unfavorable results have thus far been obtained with nitrates. Stable manure has given the best results; a plat treated with horse manure at the rate of about 20 tons per acre yielded at the rate of about 16 tons of tubers per acre—just double the yield of a check plat in the same experiment. Coffee pulp, rotted in the heap and applied in the hill, gave a yield of 12.4 tons per acre. A "complete" chemical fertilizer applied broadcast before planting gave a yield of 11 tons per acre.

FIG. 1.—ROOT SYSTEM OF YAUTIA, SHOWING WHOLE SYSTEM, TOP, MADRE, AND TUBERS.

FIG. 2.—DISEASED AND HEALTHY YAUTIA PLANTS.

HARVESTING.

The usual method of harvesting yautia is by hand pulling, supplemented by the use of the mattock. (Pl. III, fig. 2.) The leafstalks of the mature plant are grasped in both hands, and if the soil is moist or sandy, one strong pull brings up the entire root system; if some tubers break off from the rhizome and remain in the ground they are readily brought out with a blow or two of the hoe. If the soil is hard it may be necessary to loosen it with a hoe on one side before pulling with the hands. A vigorous shake after removal from the ground generally serves to break off all the mature tubers from the central rootstock, their weight causing the narrow, brittle base to snap off close to the parent root; this is especially true as regards the Rolliza variety. The small tubers which may still adhere are given a quick thrust with the thumb or a light blow with the fist. In loose soil one man can gather the tubers from 5 to 10 plants per minute; that is, 1,000 to 2,000 pounds of tubers per hour. The leaves are usually left attached to the "madre" for some days after harvesting; then they are cut off about 4 to 8 inches above the top of the old root, which is thrown into a pile to await planting time, or if for market the fine roots are trimmed off with a machete and merely the tip, or "palma" is reserved for the seed pile, while the edible portion is sold along with the tubers. (Pl. IV, fig. 1.)

In some of the British West Indies, especially Trinidad, another method of harvesting, called "castration," is sometimes employed; this consists in removing the mature tubers from the plants in situ by means of the machete. Though many of the feeder roots are necessarily severed in this operation, the plant appears to suffer only a slight check, and within six to eight months another crop is ready; in rich soil it is said even a third crop may be gathered from the same plant, making a yield of some 30 tons of tubers per acre in about eighteen to twenty-four months. This method has given good results at the station grounds with the variety called Rolliza.

A similar method is commonly practiced by the natives with the Guinea yam, though the second crop obtained is usually planted instead of being used for food.

YIELD.

While single plants may yield as high as 6 or more pounds of tubers, the average for common varieties in ordinary soil may be reckoned at 2 to 3 pounds per hill. With 10,000 plants per acre this gives 10 to 15 tons of roots per acre. To this may be added 5 to 8 tons of the "madres," which in several varieties are sold for table use and which may be utilized as a source of starch or for fattening swine and poultry.

KEEPING QUALITY.

The tubers keep better in the ground during the dry season, and as little growth is made at this time, they are usually left and cropped when the market demands it. If kept dry after being harvested they resist rots fairly well; indeed, single tubers have been carried over six months in the station office, yet when planted sprouted readily. In Porto Rico they are seldom kept longer than a few weeks after harvesting, for there is little domestic traffic and no export trade whatever. Taniers in barrels are a common article of commerce among the British West India Islands. Single tubers have been successfully sent by mail to Queensland, Australia, to Singapore, and to the Gold Coast, British West Africa. The tubers, however, lose moisture quite rapidly when exposed to the air.

DISEASES.

All parts of the yautia excepting the parenchyma of the leaf are filled with a thick juice, which protects the plant against the attacks of insects, fungi, and bacteria. A tuber cut nearly in two transversely was recently received from Central Guatemala without a trace of decay having spread from the wound, the cells at a distance of 1 millimeter from the cut surfaces being perfectly healthy upon arrival. The juice undoubtedly has great germicidal power.

During the dry season the leaf blade sometimes shows large roundish patches of dead tissue; these usually make their appearance at or near the margin, rarely occupying the center of the blade. Concentric rings of a darker shade are generally noticeable in these spots, but thus far no fungus in a fruiting stage has been noted in fresh material. Specimens of affected leaves sent to the Bureau of Plant Industry of the United States Department of Agriculture for examination contained upon arrival *Periconia pycnosporia* and *Glœosporium* sp. It is possible, however, that this trouble is of a physiological origin, due perhaps to the lack of moisture and to impeded sap circulation in the leaf tissue.

A white mycelial growth is frequently found on the surface of the tubers and rhizomes; on the former the white threads seem to do no injury whatever, but about the top of the rootstock there are frequently to be found patches of agglomerated hyphæ, beneath which the cortical tissue is partially destroyed. The bases of the leaves are rarely attacked, but in a few cases have been noted as affected by a soft rot. "Heads" showing any trace of the yellowish or whitish areas caused by fungus mycelium should be discarded in planting.

White mycelial growths are frequently in evidence on yams, cassava, etc., and were present on rhizomes of a yautia recently received from West Africa.

The most serious disease affecting the yautia of Porto Rico is known as "el mal," and is probably of bacterial origin. (Pl. IV, fig. 2.) The point of attack is the base of the rhizome; the fibro-vascular bundles become clogged with masses of bacteria and broken-down cells, gradually assuming a dark-brown color. From three to six months may elapse before the entire rootstock is affected. The result of this infection is the gradual spreading of the decay throughout the root stem and the consequent death of the leaves. The tubers, however, are rarely attacked, and if left in situ throw up healthy shoots around the old "madre." Even when slightly attacked the rootstock becomes unfit for table use. It should be fed to swine or burned, and neither the "heads" nor the offsets should be saved for planting. This may be identical with the disease prevalent in some of the British West India Islands caused by *Peronospora trichotoma*.

COMPOSITION.

Analyses of two samples of yautia have been made at the Maine Experiment Station, and the results given below are quoted from unpublished material. A white variety contained 85.9 per cent edible portion and 14.1 per cent refuse, i. e., parings. A yellow variety contained 76.9 per cent edible portion and 23.1 per cent refuse. In the preparation of ordinary Irish potatoes and sweet potatoes for the table, the edible portion constitutes on an average 80 per cent and the parings or refuse 20 per cent of the tuber. The following table shows the composition of the two varieties of yautia analyzed, calculated to a uniform basis of 70 per cent of moisture, and includes for purposes of comparison the composition of Irish potatoes and sweet potatoes:

Composition of yautias and potatoes.

Yautia and potato.	Water.	Protein.	Fat.	Total carbohydrates.		Ash.	Fuel value per pound.
				Sugar, starch, etc.	Crude fiber.		
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Calories.*
White yautia	70.0	1.7	0.2	26.3	0.6	1.2	529
Yellow yautia	70.0	2.5	.2	26.1	.6	.6	538
Irish potato	78.3	2.2	.1	18.0	.4	1.0	385
Sweet potato	69.0	1.8	.7	26.1	1.3	1.1	570

The analyses show that yautias do not differ materially in composition from the potatoes. As is the case with potatoes, carbohydrates constitute the chief nutritive material. An examination of the yautias shows that the principal carbohydrate present is starch.

USES.

Without the yautia the people of the interior of Porto Rico would be largely dependent upon one native article of diet—the Chamaluco, or Mafafo banana. Unlike the yam, the yautia may be cropped at almost any time of the year; and unlike either the yam or the sweet potato it can be grown in moist soil along the beds of streams in the clayey soils of the coffee districts, as well as in the swampy alluvium along the rivers near the coast.

The tubers, boiled, form a large part of the diet of the laboring classes; fried, they enter into many dishes on the planter's table; unfortunately the custom of baking is comparatively rare in Porto Rico, but the large tubers when baked are highly prized in Jamaica and some of the other British West Indies. If harvested before fully developed the tubers are liable to be watery after boiling, and if left in the ground till the tip sends up a leafy shoot the old root is likely to have a strong taste and requires a longer time for cooking.

The yellow-rooted varieties, especially the Martinica, require a somewhat longer time over the fire than do the ordinary yams or sweet potatoes, but the white varieties, like Rolliza, cook in about the same time as is required for Irish potatoes. When boiled the white varieties should be removed from the water as soon as done to prevent their falling to pieces, while the Martinica or the Amarilla may be left any length of time without danger of their crumbling in the kettle. In fact, the Martinica is at its best if mashed after boiling and made into small cakes or croquettes, for otherwise, unless eaten at once while hot, its firmness is objectionable. The water in which the tubers are boiled should be well salted.

In boiling the tubers the thin skin should be removed previous to putting them into the water. When baked the mealiness and peculiar flavor of the yautia are much better brought out than in any other method of cooking; the skin may be left on in baking or roasting.

The various kinds and colors of yautia are well adapted for use in puddings, croquettes, stews, soups, purées, etc. The pink-rooted varieties make an attractive dish when served entire.

A favorite manner of serving the yautia is as follows: The tubers are peeled, boiled in salted water, and mashed; then milk, or eggs, and grated cheese are added, and the mixture is made into croquettes and fried.

Parboiled, cut in thin slices, and fried is a native method which brings out the characteristic flavor to good advantage.

In fact, the yautia may be used in any way in which the so-called "Irish" potato is used. But while there is very little difference in flavor of the many varieties of potatoes, there is considerable variation in flavor, as well as in color, among the yautia varieties.

Used as a pot herb the young leaves are a valuable addition to the list of fresh vegetables in the Tropics. Though the fleshy leaf buds and young leaves are very palatable as compared with other "greens," they may be made into a still better dish by serving in a milk or cream sauce with butter and spices. Only a very short time is required for cooking these leaves. The boiled leaves may also be fried like cabbage, and are excellent made into croquettes with eggs, cheese, and milk. The Belembe has a less rich, but a more pronounced flavor, perhaps, than any other variety. The purple leaves of the Violacea type turn to a dull purplish color when boiled.

STARCH.

As a starch plant the indications thus far are that the yautia will in a measure rival cassava. The yield per acre is usually much larger—8 to 15 tons can be reckoned on with yautia, while 5 to 10 tons per acre is all that can be expected from cassava. The gum content is greater in the yautia, but the fiber is probably somewhat less. The size of the starch grain is nearly identical in both plants, being about 0.01 millimeter in diameter.

A sample of dried tubers of the Rolliza variety sent to the Bureau of Chemistry, United States Department of Agriculture, at Washington, showed a starch content of 29.17 per cent and 62.25 per cent of moisture; the "madre" of this variety gave 17.88 per cent of starch and 72.97 per cent of moisture. These figures would not be borne out in commercial manufacture, of course, and it is doubtful if any other variety would yield so high a percentage of starch. But in our experiments with the Rolliza 20 to 25 per cent of starch is readily obtained from fresh roots.

The starch made from the white varieties of yautia is fully as white and lustrous as that from the common cassava varieties. Samples of this starch kept for one year in the station office show no deterioration.

FLOUR.

Flour made by grinding dried slices of the peeled tubers is considered more nutritious and fully as palatable as the famous cassava, or bammy cakes; it contains rather less fibrous matter and no trace of the very dangerous hydrocyanic acid which occurs even in the sweet cassavas. About 70 per cent of the peeled tuber is water; thus 10 pounds of tubers, net weight, yield, after three hours' drying in the oven, about 3 pounds of flour, which will pass through a fine sieve. This flour will keep indefinitely without becoming musty if protected from moisture.

Less than 5 per cent of the gross weight of the tuber is lost in peeling. Flour made from the red-tuber varieties should prove an attractive article in northern markets.

Yautia flour may be used like wheat flour in making puddings, muffins, croquettes, etc.; it requires rather more baking powder than wheat flour on account of its "richness."

The cost of the raw material to produce 1 pound of flour is about 2 cents.

INDUSTRIAL PROSPECTS.

In the domestic—that is, the insular—economy, the yautia already has a very prominent and almost indispensable place, but there are still many improvements possible in the line of distribution of the better varieties to those localities where less productive or less hardy sorts are now known, as well as by the breeding up of excellent sorts by selection of superior tubers. A study of the phenological adaptability of the various sorts to various soils, seasons of planting, and climatic districts will prove of value.

An industry like the manufacture of starch or flour from yautia, which would increase the demand for this product, would result in great benefit to the poorer classes of landholders, who can now find a market for their surplus only in the larger towns. The sale of the product from even a half acre or so would furnish means with which the indigent native in the interior districts could obtain meat and the comforts which are usually so deplorably lacking in his domestic economy.

Judging from the results of experiments on a small scale, which have from time to time been made toward the introduction into the United States of yams and other distinctly tropical foods, much advertising and commercial enterprise would be required to successfully introduce the yautia either as a fresh tuber or in the form of starch or flour into the domestic economy of the people of the United States. However, if a demand could be created in the Eastern States for yautia products, it is more than possible a trade would spring up which would greatly benefit Porto Rico and Cuba and add another to the list of important new foods from the Tropics.

Since the yautia is almost entirely unknown in tropical Asia and Africa, its introduction there should prove of great importance. Tubers of Rolliza have already been sent to Manila, Singapore, Queensland, Lagos, and the Gold Coast of West Africa. About fifteen varieties have been sent to Hawaii, where they are reported as growing well and thus far are resistant to the taro root disease which causes the loss of nearly one-half of the crop of that staple article of the Hawaiian market. The better varieties have been distributed in several districts of Florida, Arizona, and California, with considerable success; but since at least nine months are required for the maturing of most varieties, the area in the United States adapted to their culture must needs be very limited.

SUMMARY.

The yautia is one of the world's oldest cultivated crops. It seldom flowers and never produces seed. The cultivated varieties are not found in a wild state.

It is native to tropical America and is scarcely known outside of this district. Its distribution to other parts of the world is being undertaken.

Twenty-five or more varieties are known; about fifteen are commonly cultivated in Porto Rico. The tubers are white, red, or yellow.

The tuberous offsets of the rootstock are the principal edible portion of the plant, though the leaves and, in nearly all varieties, the rhizomes are eaten. The tubers are used like potatoes; the leaves are boiled and eaten like spinach; the rootstocks are used like the tubers, those of the Palma and Blanca varieties being boiled and fed to swine.

The tubers contain from 20 to 30 per cent of starch, with but a small amount of fiber and a medium amount of protein.

The crop is grown preferably in moist soil; a great variety of soils may be utilized, however, and 6,000 to 12,000 plants per acre may be set, according to the variety. The time for reaching maturity varies from eight to twelve months.

The yield per acre is from 7 to 15 tons in ordinary soil.

The "head," or top of the rootstock, is preferred for planting; the tubers or any part of the rhizome system possessing "eyes" may be used.

In harvesting, the whole plant is pulled from the soil by hand and the attached tubers broken off by shaking or by striking with the hand; any tubers remaining in the ground are removed with a hoe. Ripe tubers may be removed from the plant in situ, and another crop may be taken from the same plants without replanting; this method is practiced only in rich soil.

Tubers may be left in the ground in the dry season for six to twelve weeks after ripening. Harvesting is usually done in the dry season, from December to May. Tubers keep well if kept dry after digging.

The crop has no serious fungus nor insect pest.

Its introduction into the frostless region of the United States is possible. The fresh tubers may be shipped to the Eastern and Central States.

Fresh tubers yield about 30 per cent of flour; this may be shipped to any point. The cost of raw material to produce 1 pound of flour is about 2 cents.

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